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Original Article

PERFORMANCE EVALUATION OF SMALL TRACTOR-OPERATED ROTOSLASHER FOR PADDY

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ABSTRACT

A large portion of crop residues are burnt in the farming fields due to non-availability of labor and high cost of removal of residue. Burning of crop residues cause environmental pollution as well as increase in the loss of plant nutrients and deterioration of soil quality. Therefore, appropriate management of crop residues assume a great significance. Rotoslasher is widely used for shredding the crop residues into small pieces and their performance study is an important factor to suit local condition. The field experiments were carried out to evaluate the performance of small tractor-operated rotoslasher in paddy fields. The performance of rotoslasher in terms of the length of chopped material, uniformity of spreading and fuel consumption were investigated with respect to change in the number of blades, viz., 2, 3 and 4, rake angle viz., 0°, 15° and 30° and peripheral velocity, viz., 18.54 m s^{-1}, 22.82 m s^{-1} and 26.97 m s^{-1} for paddy stubbles. 4 blades with 0° blade rake angle and 28.60 ms^{-1} peripheral velocity recorded lowest value of length of chopped material than other combinations. Straw was uniformly spread in the field at all peripheral velocity and all number of blades with respect to the rake angle. The experimental results revealed that fuel consumption was increased by increasing the number of blades from 2 to 4, with decreasing rake angle (30° to 0°) at increasing peripheral velocity (18.54 m s^{-1} to 26.97 m s^{-1}) for paddy stubbles.

KEYWORDS: Small Tractor Operated Rotoslasher, Uniformity of Spreading & Fuel Consumption

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INTRODUCTION

Approximately 500–550 Mt of crop residue is generated from the production of 110 Mt of wheat, 122 Mt of rice, 71 Mt of maize, 26 Mt of millets, 141 Mt of sugarcane, 8 Mt of fiber crops (jute, mesta, cotton) and 28 Mt of pulses. Similarly, the partially green crop residue, which has a narrow carbon: nitrogen ratio (30:1) and which facilitates composting can serve as an alternate to high-energy derived fertilizer and provide a viable option for eco-friendly organic farming (Devi *et al*., 2017). Karnataka produces around 36.6 Mt of total crop residue. About 4.3 Mt rice residues and 0.7 Mt cotton residues contributing from total crop residue generation.

In India, most of the farmers use 45 to 60 kW tractors, which are overpowered for small and marginal farmers. Further, their price and operational cost is more and beyond the reach of many farmers. Bullock power needs replacement because of its increasing operational cost and low efficiency. Thus, for Indian condition, mini or small tractor (10 to 20 kW) may be best suited for small and marginal farmers. The ownership of small tractor costs 40 to 50% lesser than the popular tractor of medium size and requires 25% and 60% lesser costs in fuel and maintenance, respectively, (Sahay, 2008). It is the prodigy of soil of India that it provides food to 1.3 billion

population with just an average farm size of less than 1.08 ha. Small and marginal land holdings (< 2 ha) contribute to 86% of the total operational landholdings and this ever led the countrymen to focus on agricultural mechanization. The present farm availability of Indian agriculture is about 2.24 kW ha^{-1} during 2016–17 (Mehta *et al*., 2019). At present, the primary and secondary tillage, sowing and planting, harvesting and threshing operations have seen substantial growth in mechanization for all the major crops. Since mini or small tractor is a new name to Indian agriculture, it is necessary to develop various implements matching it.

After harvesting the crop, these machines cut the stalk and distribute them on the field surface. Slashing of crop can be performed in a short period of time, which is of great advantage, especially in the early decomposition of the crop residue in the field to increase the soil nutrient content. The rotoslasher consists of blades pivoted horizontally on a vertical shaft and moves forward in the field. The efficiency of a rotoslasher is the ability to cut the stubble (crops or straw or stalk) into small pieces. There is a need to develop a small tractor operated rotoslasher and evaluate its performance. Hence, keeping the above factors in view, an attempt has been made to evaluate the performance of a tractor-operated rotoslasher matching mini tractor for shredding operation for paddy stubbles.

MATERIALS AND METHODS

The development and fabrication of small tractor operated rotoslasher has been carried out in Department of Farm Machinery and Power Engineering, College of Agricultural Engineering, University of Agricultural Sciences, Raichur during the year 2018–19.

BRIEF DESCRIPTION OF MACHINE

The developed rotoslasher had knives rotating in a horizontal plane with direction of travel. This rotoslasher is mainly designed for shredding the agricultural crop residues. The straight blade is used for shredding and it is mounted on rotor hub. The rotoslasher gear box receives 540 rpm from tractors PTO; which is converted into 490.91 rpm by suitable gear drive. A universal joint was used to connect tractor PTO to the gear box input shaft. Power from tractor PTO is transmitted to the gear box input (mounted on the main frame of machine) shaft. Power from gear box output shaft to rotary unit was provided by rotor assembly fitted on output shaft (Figure 1). The schematic view of developed rotoslasher as shown in figure 2. The overall specifications of small tractor operated with rotoslasher, as furnished in tables 1 and 2, respectively.

SELECTION OF VARIABLES

Performance of small tractor-operated rotoslasher depends on many factors, *viz.*, number of blades, peripheral velocity of rotary blade and rake angle. For achieving maximum shredding efficiency and minimum length of cut of crop stem by rotoslasher was investigated with the following selected variables. The field experiments carried out with three levels of number of blades, *viz.*, 2, 3 and 4, three levels of peripheral velocity, *viz.*, 18.54, 22.82 and 26.97 m s^{-1} and three levels of rake angle, *viz.*, 0°, 15° and 30°. The length of chopped material, uniformity of spreading and fuel consumption was recorded during the field investigation.

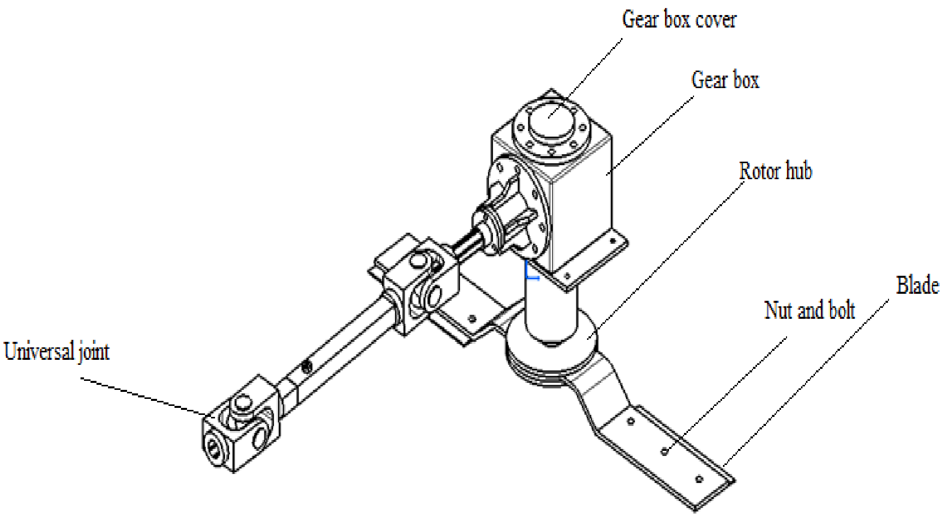
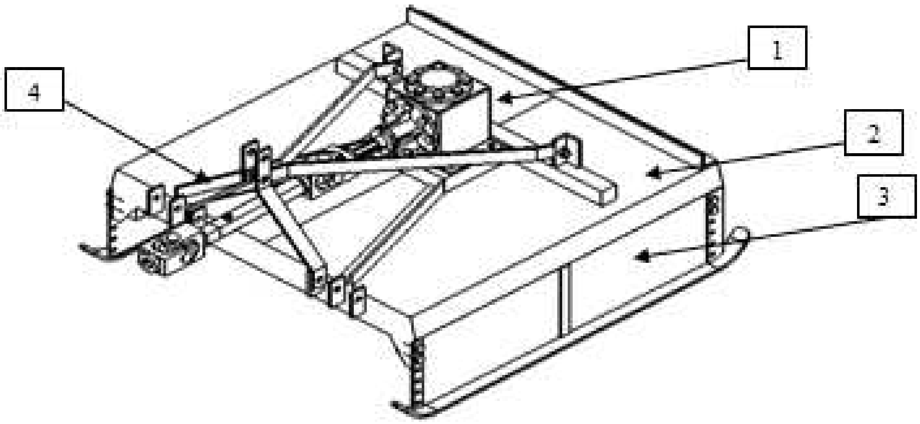


Figure 1: Power Transmission System of Developed Rotoslasher.



1: Gear Box, 2: Main Frame, 3: Skid, 4: Hitch Pyramid
Figure 2: Schematic View of Rotoslasher for Paddy Stubble.

Table 1: Specifications of Small Tractor

Sl. No.	Parameter	Description
1.	Power source used	Small tractor
2.	Make	Kubota
3.	Model	A211N
4.	Maximum PTO power (kW)	15.7
5.	Drive wheels	4WD
	Type of tyres	Pneumatic and traction
	Size	Front 5–12
		Rear 8–18
	Track width (mm)	700
6.	Min. turning radius (with brake) (m)	2.1
7.	Traveling speed (km h^{-1}) Max.	18.8

Table 2: Overall Specifications of Small Tractor-Operated Rotoslasher

Sl. No.	Parameters	Value
1.	Overall dimensions (L x W x H), cm	160 x 160 x 78
2.	Weight (kg)	250
3.	Power source (kW)	15.7
4.	Type of blade	Straight
5.	Number of blades	2–4
6.	Number of rotor hubs	1–3
7.	Material used for cutting blade	High Carbon Steel
8.	Type of gear used	Bevel

Experimental Procedure for Evaluating Small Tractor Operated Rotoslasher for Paddy

The field performance evaluation of small-tractor operated rotoslasher for paddy was carried out in farmers' fields of Raichur, Karnataka. The independent variables that affect the performance of small tractor operated rotoslasher and levels of selection of variables were made on the basis of preliminary traits. The dependent variables for performance assessment of small tractor-operated rotoslasher for paddy stubbles were length of chopped material, uniformity of spreading and fuel consumption. An experiment of 3^3 randomized block design was used to conduct the experiments and test the significance of variables and their interactions.

Length of Chopped Material

Length of chopped material was measured on the field at five different locations and the mean values were recorded.

Uniformity of Spreading

For measuring uniformity of spreading, the chopped straw behind the width of cut of the machine was divided into three equal plots of size 1 x 1 m^2 and weight of chopped straw in each plot was recorded using a weighing balance having a least count of 10g. Three replications of this procedure were done in each plot. Uniformity spreading in the m^2 area was measured by subtracting the coefficient of variation (%) from 100%.

Fuel Consumption

Fuel consumption was quantified by adopting standard procedure. The fuel tank was filled to its full capacity before and after the test. Amount of refueling after the test was measured, which was the actual fuel consumption for test. The fuel consumption expressed in $l\ h^{-1}$.

RESULTS AND DISCUSSIONS

The data collected during machine operation in the field was statistically analyzed and results are discussed as follows:

Effect of Number of Blades, Rake Angle and Peripheral Velocity on Length of Chopped Material

The analysis of variance showed that the number of blades, rake angle and peripheral velocity were significant at 5% level of significance and all interactions were significant at 5% level of significance.

The effects of different number of blades and rake angles on the length of chopped material with peripheral velocities of blades are presented in figure 3. It was observed that the length of chopped material decreased as number of blades increased for all rake angles. However, the minimum length of chopped material was observed with rake angles 0°

at 26.97 m s^{-1} peripheral velocity for four numbers of blades. Maximum length of chopped material was observed with rake angles of 30° at 18.54 m s^{-1} peripheral velocity for two numbers of blades. The length of chopped material decreased as the number of blades increased because of more contact of blade surface to the stubble, thus the number of beating actions on the stubble was more. Hence, the length of chopped material decreased at higher number of blades. The length of chopped material increased as the rake angle increased, which is due to the sliding of stubbles on blade area, which results in inappropriate length of cut. The length of chopped material was less, as the peripheral velocity increased due to the increase in number of impacts of blade to flail the stubble shredding. The results are in agreement with the findings of Senthilkumar *et al*. (2010) and Sridhar and Surendrakumar (2016).

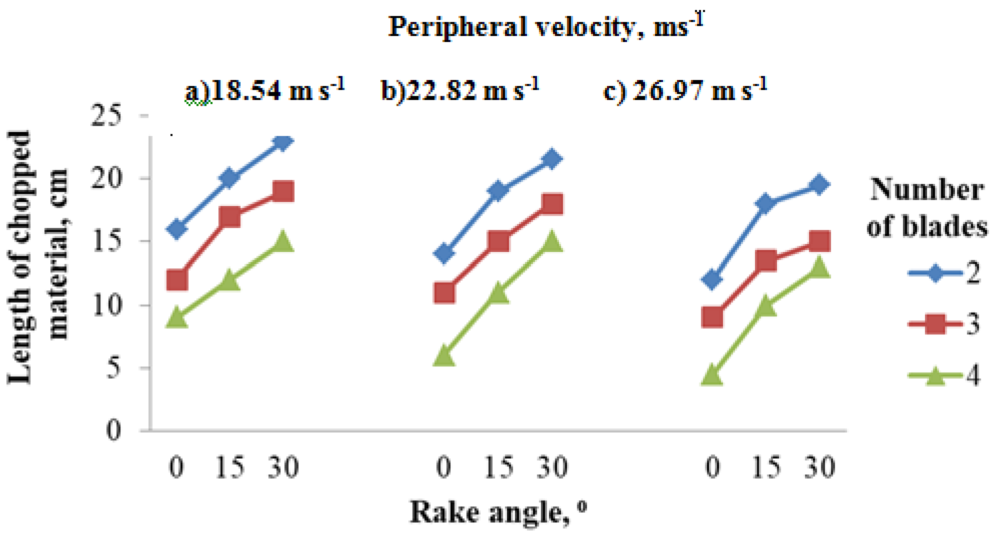


Figure 3: Effect of Different Peripheral Velocity on Length of Chopped Material.

Uniformity of Spreading

The analysis of variance showed that the main effect of each factor of number of blades, rake angle and peripheral velocity were significant, indicating the influence of each factor on uniformity of spreading.

The effects of different number of blades and rake angles on uniformity of spreading at different peripheral velocities of blades are presented in figure 4. It was observed that the uniformity of spreading increased as the number of blades increased for all rake angles. However, higher uniformity of spreading was observed with rake angle of 0° at peripheral velocity of 26.97 m s^{-1} for four number of blades. It was observed that with increase in number of blades from two to three at 18.54 ms^{-1} and 22.82 m s^{-1} peripheral velocities, the drastic increase in uniformity of spreading was observed for 15° rake angle. The uniformity of spreading decreased as the rake angle increased because less stubble was cut, which may lead to variation in the amount of straw collected in a specified area. At 26.97 m s-1 peripheral velocity, there was drastically increased uniformity of spreading at 15° and 30° rake angles, as the number of blades increased from two to three, which may be due to more number of strokes of blades with increase in peripheral velocity, which directly influenced the straw available on the field, which was more, which lead to less variation in the amount of straw collected (was more) in the specified area, whereas uniformity of spreading decreased as the number of blades increased from three to four at rake angles 15° and 30° at 26.97 m s^{-1}peripheral velocities, which may be due to that as number of blades increased from three to four. The time required for cutting was less, which might lead to the decrease in uniformity of spreading.

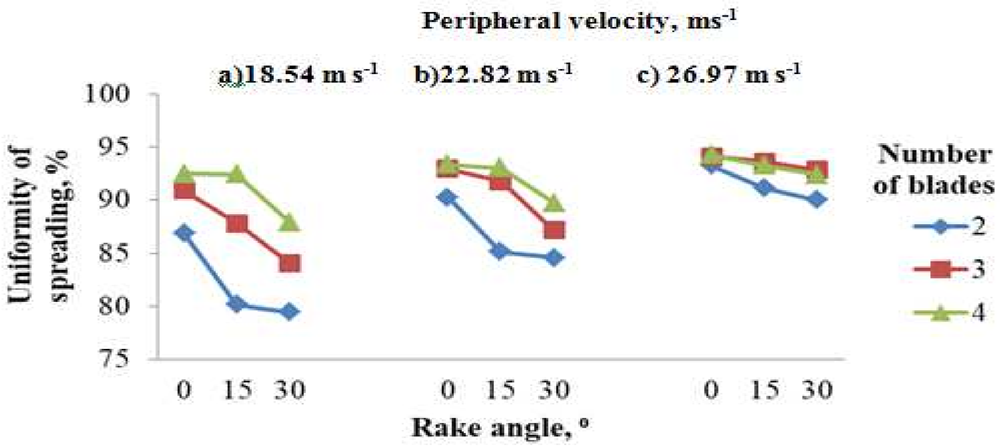


Figure 4: Effect of Different Peripheral Velocity on Uniformity of Spreading.

Fuel Consumption

The analysis of variance showed that the main effect of each factor of number of blades, rake angle and peripheral velocity were significant, indicating the influence of each factor on fuel consumption.

The effects of different number of blades and rake angles on fuel consumption at different peripheral velocities of blades are presented in figure 5. It was observed that the fuel consumption increased as number of blades increased for all rake angles. However, less fuel consumption was observed with rake angle of 30*°* for 18.54 m s^{-1} peripheral velocity for two numbers of blades. Fuel consumption increased with increase in number of blades for all rake angles. As rake angle decreases, fuel consumption increases. The fuel consumption decreased as the number of blades decreased because of mass flow rate of stubble coming to machine decreased, thus less energy required for cutting the stubble. Hence, the fuel consumption decreased at lesser number of blades. The fuel consumption decreased as the rake angle increased due to stubble slides on cutting edge and leaving the stubble uncut. Hence, the fuel consumption decreased at higher rake angles. The fuel consumption was observed to be higher with the increase in peripheral velocities. The results are in agreement with the findings of Dogherly *et al*. (1986) and Dalmis *et al*. (2013).

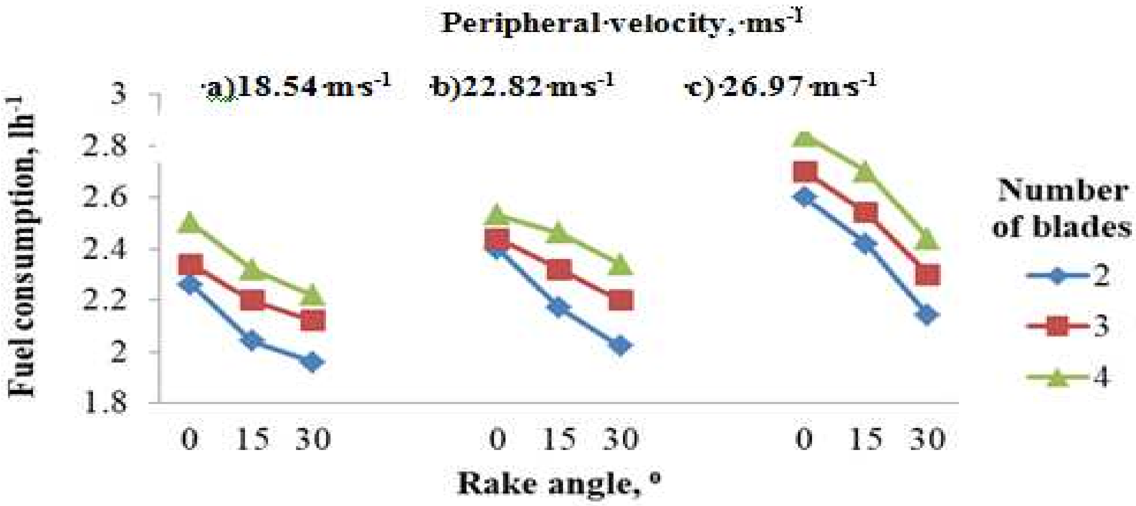


Figure 5: Effect of Different Peripheral Velocity on Fuel Consumption.

CONCLUSIONS

- It was observed that the length of chopped material was found to be minimum for 4 number of blades with a 0^{o} rake angle at 26.97 m s^{-1} peripheral velocity.
- The maximum uniformity of spreading was achieved at 26.97 m s^{-1} peripheral velocity with 0^{o} rake angle for 4 number of blades.
- It was recorded that the maximum fuel consumption was recorded at four numbers of blades at 26.97 m s^{-1} peripheral velocity with 0^{0} rake angle, and minimum fuel consumption was observed at two numbers of blades with 30^{0} rake angle at 18.54 ms^{-1} peripheral velocity.

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